

## Episode 13

### **"Makimoto's Wave": The Cycle of Standardization and Customization**

In the semiconductor industry, market situations suddenly and drastically change from time to time, from overheated situation with continued fine days with clear blue skies to depression with days of continued pouring rains. The market conditions between 1984 and 1985 changed dramatically in this way, and drastically changed from the best condition of the market to the worst.

Amid such a sudden change in the market situation, there was a large personnel change within Hitachi in February 1986. Masao Uchihashi, GM (General Manager) of Musashi Factory became GM of Semiconductor Division, and I was appointed to GM of Musashi in place of him.

Since our factory's deficit continued from the previous year to this year, it became a serious problem of the whole company. It was the common understanding inside Hitachi at the time that "the responsibility of the deficit resides with the factory GM." And I was dismissed from GM of Musashi Factory in one year and was transferred to GM of Takasaki Factory. This factory was like a younger brother of Musashi, so it was understood by everyone that this change was clearly a demotion.

My farewell ceremony was held on February 20, 1987, in the customary procedure, with thousands of employees who gathered on the roof of the factory building. It was a very cold day and snow pile still remained in the corners of the rooftop. I cannot forget the regretful feeling of the greeting in the ceremony.

At that time, the normal order of personnel promotion for the GM class in our Division was to start from GM of Takasaki Factory to GM of Musashi Factory, and then to GM of Semiconductor Division. My case was exact opposite; from Musashi to Takasaki. It seemed to me that it was more or less an indication of my last post at Hitachi. I fell into the bottom of the valley from the top of the mountain. Although the Takasaki factory was also suffering from the deficit, the situation was somewhat different from Musashi. Bipolar products which were the main products of Takasaki were mostly for domestic market and the ratio of consumer application was higher than in the case of Musashi. We started a project to foster "fighting devices" in order to overcome the deficit and to make a next leap forward. We named it TFD: Takasaki Fighting Device. We immediately started the campaign with the target of creating world top products, under the clear selection and concentration strategy. A variety of measures including this TFD project worked successfully, and in the following year we could return to a level of nearly normal profitability.

For some time after I moved to Takasaki Factory, I attempted to examine structural transformation of the semiconductor industry from various viewpoints.

The focal point of my thinking was "Why semiconductor market fluctuates so violently like this?" After giving intensive thoughts from various viewpoints, I came up with a concept of cyclic nature of semiconductor industry which would be called "Makimoto's Wave" later.

As shown in Fig.13.1, it is a cyclic nature of semiconductor industry in which the “age of standardization” and the “age of customization” alternately appear approximately every ten years. These changes involve structural transformation of the semiconductor industry, and impact on the market situation, too.

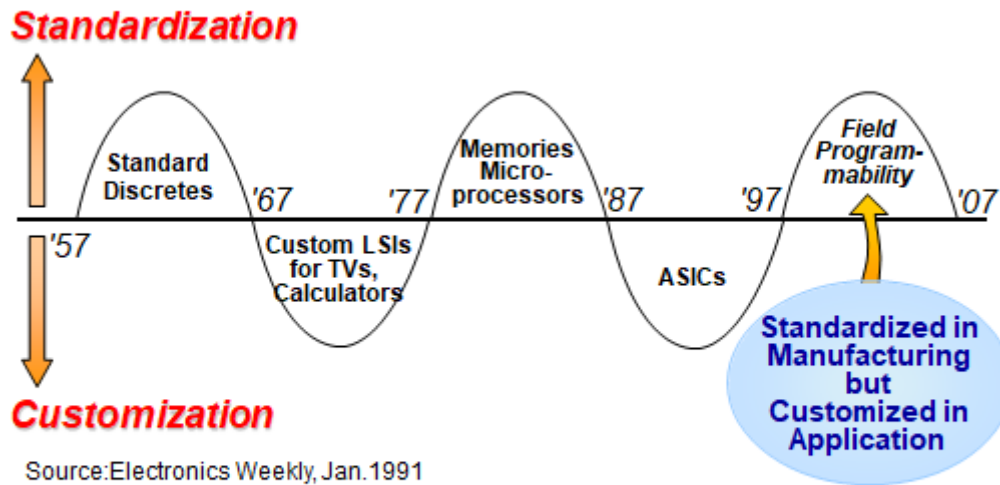


Fig. 13.1 Makimoto's Wave

It was 1987 when I got the idea of the wave. At that time, the excessive production of memory triggered the market deterioration and alarm bells were being set in the industry against making standard products only. Venture companies such as LSI Logic were launched, and the word ASIC (Application Specific IC) symbolized the rise of the new trend.

I recognized that the trends of the semiconductor industry could be classified as follows from the viewpoint of "standardization" and "customization".

1947-1957: Infancy of semiconductor industry

1957-1967; “Standard oriented era”, centering on transistors

1967-1977: “Custom oriented era”, centering on such custom products such as calculator LSIs

1977-1987: “Standard oriented era”, centering on microprocessors and memories

And I further extended such past trends to incorporate the following predictions: 1987-1997: "Custom Oriented Era" led by ASIC

1997-2007: "Standard Oriented era" led by field programmable products

Turning back from today, programmable products which centered on FPGAs (Field Programmable Gate Arrays) started to rise rapidly from the latter half of the 1990s, and it is recognized that “wave prediction” was correct on the whole.

This concept is also the background behind F-ZTAT microprocessor which was commercialized by Hitachi in this period. (F means flash memory, ZTAT means zero-TAT or zero turn-around time).

Conventional on-chip mask ROM was replaced by on-chip flash memory in the F-ZTAT structure, and it enabled customers to introduce new products into the market in a very short time. F-ZTAT microprocessor is now the main product of Renesas Technology Corporation.

Also at NEC Electronics, they developed a strategy corresponding to this, and started a campaign which they called "All Flash declaration".

(Note: Renesas Technology and NEC Electronics merged into Renesas Electronics in 2010.)

In the decade from the latter half of the 1990's, the conversion of on-chip memories from mask ROM to flash memory was accelerated in the industry, endorsing the Wave's prediction.

At this point, I would like to mention that David Manners of Electronics Weekly (UK) made a great contribution for Makimoto's Wave to be widely known in the world.

When I took his interview in 1990, I explained about the concept of the wave and he was very interested in it and sympathized with my thinking. In January 1991 he not only took it up on the top page of The Electronics Weekly, but also he named it "Makimoto's Wave." And in 1995, we wrote a book together based on this concept under the title of "Living with the Chip". The Japanese version was published as "Digital Revolution" from Nikkei BP company in 1996. In this sense, it can be said that "Makimoto's Wave" is a collaborative work between David Manners and me.

By the way, our friendship has continued since then, and we jointly published another book, "Digital Nomad" in 1997, which was also published in Japanese from Kogyo Chosa Kai in 1998.

Now, why does semiconductor trend swing between "standardization" and "customization"? A model of "semiconductor pendulum" was devised to explain it as shown in Fig. 13.2.

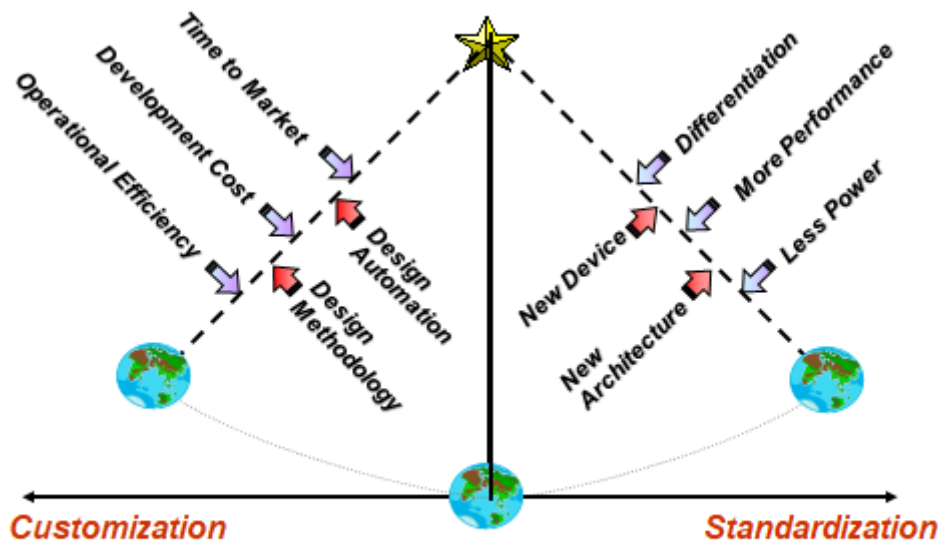


Fig. 13.2 Semiconductor Pendulum

In Fig. 13.2 are shown a force and its reactive force applied to the pendulum. For example, with advances in design automation technology (such as EDA tools) and design methodologies (such as gate arrays), customization becomes easier, and the pendulum is pushed toward customization side. However, if it goes too far, it will be pushed back to the opposite side by customer needs such as "faster product introduction to market" and "lower development cost".

Conversely, the emergence of processor architecture (such as MPU) and new devices (such as FPGA) will be a force to push the pendulum towards standardization side. However, when it goes too far, the customer needs of "more differentiation" and "lower power" push back the pendulum again to the opposite side.

As a result, the pendulum showing the trend of standardization and customization has swung to each side every 10 years (20 years as a cycle) caused by technological progress and changes in the market structure of semiconductors.

"Makimoto's Wave" began to draw attention in the semiconductor industry since the latter half of the 1990's when FPGAs and the like began to rise. However, it has become an unexpected development for me that it has got a lot of attention in the computer and the communication communities as well since 2000. At this time, "Configurable Computing" has become a major trend in the computer field, and "programmability" of devices gained a lot of attention along with that trend.

At the beginning of such a movement was FPL 2000 conference held in Austria in August 2000, and I was invited to deliver a key note speech there centering on the wave concept (FPL stands for Field Programmable Logic, an academic Society under IEEE).

The move was taken over by the conference FPT 2002 in Hong Kong in December 2002 (FPT stands for Field Programmable Technology, an academic Society under IEEE).

Furthermore, I had opportunities to introduce the wave concept in the key note speeches at big conferences including "Computer Innovation" in Beijing in November 2005 to commemorate the 60th anniversary of computer, an IEEE organized computer workshop in Hakone in January 2006, Super Computer Conference (SC 06) in Tampa, USA in November 2006, and International Super Computer Conference (ISC 07) in Dresden, Germany in June 2007.

Also, in May 2008 I was invited for a speech at the Wireless Communication Technology Forum in Tokyo. The major reason was that "Reconfigurable radio" realized by programmable devices has become a big theme.

Now, the time range of the original Wave which was made public in 1991 is covered up to 2007 and stops there, and recently, I receive many questions "What will be the next wave?"

Technologies and markets have been diversifying these days, so it will be no longer a simple cycle change as in the past. It is expected that standardization and customization orientations will coexist to some extent. In other words, while standard-oriented field programmable products continue to grow, it is expected that new types of custom-oriented products will be launched.

Products that are predictive of such trends are already appearing. These products have common features such as "circuit configuration with extremely high regularity", "customization with small number of mask layers", "extremely cheap development cost", and "short development period".

As one of the products based on this concept, Altera's "Hard Copy Structured ASIC" should be mentioned. Marketing activities have already been started, and it is said that design-ins are being progressed in a wide range of application fields that FPGA has not covered before.

In addition, E-shuttle Company (a joint venture between Fujitsu and Advantest) has formulated a strategy to develop new fields by a mask-less method.

Both are noted as the moves leading a new custom-oriented wave.

Furthermore, new packaging technologies such as TSV will also intensify new customization move. These technologies will lead to SiP (system in package) in a broad sense. Advances in semiconductors have been dominated mainly by integrating as many elements as possible on a chip in two dimensions, but from now on it will be possible to incorporate heterogeneous functions in the form of three-dimensional integration, enabling better ability to respond to system needs. The era of new semiconductors is about to begin.

Author's Note as of January 2017

For the development of Makimoto's Wave after 2007, please refer to the following paper:

"Implications of Makimoto's Wave", IEEE Computer, December 2013

This is one of five selected papers on "Computing Laws" which appeared on the special issue of the IEEE Computer Magazine featuring "Computing Laws Revisited". This paper, with author's explanation, will be exhibited in our museum at a later date.

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Note: The original version of this article was first published, in Japanese, on the Semiconductor Industry News (Sangyo Times Co., Ltd.) from July 12, 2006 to January 9, 2008.